Estimating Infant Blood Lead Levels from Baby Food Consumption: A Biokinetic Model Analysis

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Abstract:

Background and Purpose: There are many routes through which a child may be exposed to lead, including ingestion, inhalation, and dermal absorption. Sources of childhood lead exposure include soil, house dust, water, secondhand smoke, consumer products, and food. While lead occurs naturally in soil, its presence is also a result of historical uses of lead in paint, gasoline, and industry. Lead enters the food system when it accumulates in vegetables, fruits, and grain crops via plant uptake from soil. These are all core ingredients in baby food; consequently, some baby food products may inherently have detectable levels of lead. Consumer baby food products are intended for children six months to two years of age, a critical period of susceptibility to lead. Young children have lower body masses which puts them at risk for a higher lead body burden following exposure. They are also more likely to ingest soil and dust due to hand-to-mouth activities, thus heightening their risk for lead exposure.

Lead has been found to be present at varying levels in consumer baby food products. A 2022 study by Parker et al. sampled and analyzed baby food products across multiple food categories (fruits, grains, leguminous vegetables, and root vegetables) available in stores. The authors found that lead levels varied across and within food categories, with root vegetable products containing the highest lead levels. Blood lead levels (BLLs) in U.S. children aged 6 months to 2 years are not specifically tracked in the National Health and Nutrition Examination Survey (NHANES) BLL monitoring program. However, using reported lead levels in baby foods, biokinetic models can be used to estimate the contribution of lead in baby food products to infant BLLs. In this analysis, the U.S. Environmental Protection Agency's (EPA) All Ages Lead Model (AALM) was used to evaluate the contribution of baby food to a child's total BLL; other common lead exposure pathways (e.g., house dust ingestion) are also considered. BLL modeling results for male and female children are compared to the Centers for Disease Control (CDC) blood lead reference level (BLRV) of 3.5 µg/dL, and the variable influence of different food products (e.g., root vegetable products vs. fruit-based products) is evaluated.

Methods: Lead levels in commercially available baby food products from Parker et al. (2022) were used as dietary inputs. Age-specific (<1 year; 1 - <2 years) daily lead intakes from baby food products (µg/day) were derived using average daily doses reported in Parker et al. (2022) and mean bodyweights reported in the U.S. EPA's Exposure Factors Handbook. Specifically, average daily doses and consumer-only intake rates for fruits, grains, leguminous vegetables, and root vegetables were used. Total daily lead intake was considered to be the sum of estimated daily lead intake from all food categories (fruits, grains, leguminous, and root vegetables). It was assumed that consumption of baby food products occurred from six months to two years of age; because the model inputs begin at age zero, the U.S. EPA default dietary lead intake (2.66 µg/day) was assumed from ages zero to 6 months. Default lead levels specified by the U.S. EPA were assumed for water (0.1 µg/L), and air (0.1 µg/m^3) from ages zero to two. The national mean lead concentrations for soil (135.3 µg/g) and house dust (124 µg/g) from the 2018-2019 American Health

Homes Survey II (AHHS) were chosen as inputs for the model's soil and dust parameters (Sowers et al., 2024).

Results: Estimated category and total daily lead intakes were calculated using median baby food product lead concentrations. Leguminous vegetables contributed the least to estimated daily dietary lead intake, accounting for 7% (0.26 µg/day) and 8% (0.65 µg/day) of daily lead intake for a child less than 1 year and a child 1 to 2 years, respectively. Grain products consistently contributed to the majority of daily dietary lead intake, accounting for 34% (1.22 µg/day) and 38% (4.16 µg/day) for a child less than 1 year and a child 1 to 2 years, respectively. The percent contributions from fruit and root vegetable products decreased as age increased. Fruit accounted for 26% (0.93 µg/day) and 22% (1.92 µg/day) of daily lead intake for a child less than 1 year and a child 1 to 2 years, and root vegetables accounted for 32% (1.14 µg/day) and 22% (1.88 µg/day) of daily intake for a child less than 1 year and a child 1 to 2 years.
For a hypothetical child consuming baby food products, the maximum estimated BLLs were 3.2 µg/dL (F) and 3.1 µg/dL (M). Both of these maximum BLLs are below the CDC BLRV of 3.5 µg/dL. To assess the influence of the soil and dust on the estimated BLLs, an additional scenario was modeled assuming no exposure from soil and dust. Adopting 0 µg/g for soil and dust inputs, a hypothetical child consuming products with median lead concentrations had maximum estimated BLLs of 2.1 µg/dL (F) and 1.9 µg/dL (M). When soil and dust were eliminated as sources of lead exposure, the maximum BLLs decreased by 1.1 µg/dL (F) and 1.2 µg/dL (M). Consumption of baby food products did not result in exceedances of the BLRV in any of the scenarios evaluated. The daily lead intakes used in this assessment are highly conservative, as the average daily doses were calculated assuming that baby foods accounted for all of a child's daily food consumption.

Conclusions: This assessment demonstrates that consumption of commercially available baby food products alone is unlikely to increase the risk of a child's BLLs exceeding the CDC BLRV of 3.5 µg/dL. Furthermore, the model estimates showed that exposure to baby food in combination with exposure to soil and dust lead levels representative of national conditions is unlikely to result in child BLLs exceeding the BLRV.